# Reviewing the Assumptions, Methods and Results of:

*Economic Impacts on Kansas of Diminished Surface Water Supplies to the Lower Republican River Basin Caused by Nebraska in 2005 and 2006*

By

Dr. James Pritchett

16 February 2008

Overview and Purpose:

The purpose of this document is to examine the estimates, assumptions and methods found in the document Economic Impacts on Kansas of Diminished Surface Water Supplied to the Lower Republican Basin Caused by Nebraska in 2005 and 2006 (hereafter EIA) authored by Golden, Kastens, Dhuyvetter, Leatherman, Featherstone and Johnson.

At issue are the economic damages that occurred when Nebraska presumably failed to deliver surface water supplied to Kansas. For the purposes of this document, I have used the quantity of irrigation water shortfall that Golden et al posit without any independent analysis. I do not have an opinion as to whether or not delivery shortfall is correct, but a change in the shortfall quantity could affect the total damages estimated in this report.

The EIA document estimates damages associated with reduced surface water deliveries in 2005 and 2006. The analysis focuses on two measurements: quantifying the direct impacts to farmers as a result of reduced farm profits and assessment of the indirect impact that lost farm revenues have on Kansas households. Each method will be discussed in turn.

*Estimates of Reduced Farm Profits*

Profits have been defined in the EIA as:

(1) $P = PR * Y - VC - FC$

Where P represents profit per acre for the crop being studied, Y is the crop yield, VC are crop specific variable costs and FC are fixed costs associated with the farming operations. Irrigated crops include corn, milo, soybeans, and alfalfa. Non-irrigated crops include corn, milo, soybeans, sunflowers, ensilage and wheat.

Economic loss involves the difference between expected profits under full irrigation and the actual profits. Actual profits may deviate from expected based on two management strategies:

- Farmers choose to alter their crop mix based on the expectation of no irrigation water supplied. This is especially true for the crop acres Above Lowell which were fallowed in 2005. In this case, the EIA adjusts the crop mix to dryland crops (e.g., wheat) from the standard irrigated crop mix, and

- Farmers choose to plant the same crop mix but suffer from reduced yields as a result of insufficient water deliveries.

Notably, I am unable to verify if supplemental irrigation is available to farmers within the affected area's geography. If supplemental irrigation is available, then one would expect damages to mitigated.

The geographic scope of the EIA's foregone profit analysis is focused on the Kansas Bostwick Irrigation District (KBID) as the data for prices and yields is generally taken for this area. When necessary, the National Agriculture Statistics Service (NASS) data for Jewel, Republic and Cloud counties are used in the EIA, or the north-central agriculture statistics district is referenced. I note KBID lies primarily in the Republic County of Kansas, and it appears that no acres in the KBID reside in Cloud County. The 2007 Census of Agriculture reports 43,123 acres of irrigated farmland in Republic County and the 2006 KBID annual report suggests 43,048 acres of irrigated land, so it appears that KBID irrigated lands may be a large share of the Republic County irrigated farmland.

In the section that follows, I will discuss the assumptions used for each of the profit variables listed in equation (1) beginning with the price (PR). Occasionally, I will offer an alternative measure of the profit variable and will calculate an estimate of damages based on these alternatives to be contrasted with the EIA. My analyses will be called the Alternative Analysis.

*Prices (PR)*

Prices (PR in equation (1)) play an important role in determining the actual and the potential profits for 2005 and 2006 in the KBID. In general, the price received by a farmer in the study area will be the greater of (a) the USDA Farm Service Agency (FSA) loan rate or (b) the harvest cash price for the specific crop, a choice that implicitly assumes that all farmers participate in government programs administered by the Farm Service Agency (FSA). Table 7 of the EIA reports the prices used in the EIA assessment.

Table 7's prices include the FSA loan rate and two potential proxies for the harvest cash price: the KBID price imputed from annual reports and the National Agriculture Statistics Service (NASS) district price. It appears that the KBID price data (and other data as well) is gathered using an "annual crop survey." I have not been able to independently evaluate the crop survey methodology, nor has it been described either in the EIA and or the KBID annual report. I cannot comment on whether the crop survey methodology is appropriate for calculating foregone profits to KBID farmers, but changes to these prices will alter the assessment of damages.

The crop prices used in the EIA are not found in the KBID annual report, but I was able to reproduce the KBID prices when dividing the total value of production by the total bushels produced. Because of I am unable to evaluate the representativeness of the prices, I am adopting an alternative: the greater of the NASS district prices and the FSA loan rate. The specific prices used in the EIA and the alternative analyses are listed in Table 1:

Table 1. Crop prices used in the EIA and the Alternative Analysis[a]

| | Alternative Analysis[b] (2005) | EIA[c] (2005) | | Alternative Analysis[b] (2006) | EIA[c] (2006) |
|---|---|---|---|---|---|
| | | | | | |
| Alfalfa | $ 74.00 | $ 70.00 | | $ 104.00 | $ 100.00 |
| Corn | $ 1.97 | $ 1.97 | | $ 2.62 | $ 3.00 |

| | | | | | |
|---|---|---|---|---|---|
| Silage | $ 15.21 | $ 20.00 | | $ 20.54 | $ 25.00 |
| Milo | $ 1.81 | $ 1.81 | | $ 2.95 | $ 3.00 |
| Soybeans | $ 5.36 | $ 5.00 | | $ 5.20 | $ 5.70 |
| Sunflower | $ 0.0865 | $ 0.1000 | | $ 0.1000 | $ 0.1000 |
| Wheat | $ 3.12 | $ 3.12 | | $ 4.19 | $ 4.19 |

[a]Units for the alfalfa and silage are $/ton, sunflower prices are $/lb and $/bu for all other crops.
[b]These prices are used in the alternative analysis.
[c]These prices were used by Golden et al in their assessment.

*Yields (Y)*

Total farm revenues are the product of the crop's cash price received (PR) and the crop's yield (Y). Yields are negatively impacted when available water (soil moisture, precipitation, irrigation) is below crop needs. The difference between the expected yield and the actual yields multiplied by the price represents a lost value of production. In the EIA, a documented crop-nitrogen-water relationship and model (IPYsym) is used to forecast KBID corn yields, and the forecast is fairly consistent with the trend yields also reported in the EIA. However, the authors prefer to use the KBID annual report yields in place of the crop-nitrogen-water forecast or trend yields.

In my opinion the use of the KBID yields may overstate the lost profits in 2005 for the following reasons:

(a) I am unable to verify the sampling method used in the KBID crop survey to determine if it is representative. However, these yields are greater than the NASS county yields. (see Table 2 below).

(b) In 2005, no irrigated acres were reported Above Lowell (Table 2 of the EIA), but corn yields are reported as 187 bu/ac (Table 10 of the EIA). The 2005 yield was record setting for the KBID surpassing the previous year's record of 180 bu. per acre[1]. Importantly, KBID farmers fallowed irrigated ground Above Lowell in both 2004 and 2005. The annual report provides a district-wide estimate of yields, so it may be that the fallowed ground was of lower productive quality, and simply fallowing the acres improved the district wide corn yield average that is measured in bushels per acre. The two years in which acres were fallowed (2004 and 2005) have yields well above the corn yields reported in the KBID annual report for 2003 and 2006 supporting the notion that the fallowed acres were indeed less productive acres. Therefore, applying the KBID district yields to the fallowed acres may overstate the potential productivity and profitability of the fallowed acres. Table 2 of this document lists the crop yields found in the KBID annual report.

(c) The authors have calculated the trend yield for 2005 and 2006 as 169.7 bushels per acre and the yield goal calculated using the IPYsim model is 171 bushels per acre (Table 10 of the EIA). This is in contrast to the KBID reported yield of 187 bushels per acre for 2005.

[1] From the 2006 KBID annual report.

(d) The 2005 county level average yield for Republic County (NASS) is 173 bushels per acre, in contrast to the KBID reported yield of 187 bu per ac. In 2003 and 2006, the KBID reported yields were similar to the NASS reported yields (Table 2 below).

It is my opinion that the Republic County average yield (NASS) is a better proxy for the actual yield in 2005. This yield should be applied to the Below Lovewell acres, as the Above Lovewell acres were not planted to irrigated crops.

Table 2. Corn yields used in the EIA and the Republic County Yields (NASS).

| | ***2003*** | ***2004*** | ***2005*** | ***2006*** |
|---|---|---|---|---|
| ***KBID*** | 160.7 | 180.4 | 187.0 | 162.6 |
| ***EIA Trend Yield*** | XXXX | XXXX | 169.7 | 169.7 |
| ***EIA Target Yield (IPYsym)*** | XXXX | XXXX | 171.1 | 171.1 |
| ***EIA Model Yield (IPYsym full irrigation)*** | XXXX | XXXX | 165.9 | 168.3 |
| ***Republic County Yield (NASS)*** | 157.0 | 170.0 | 173.0 | 164.0 |

The EIA suggests that insufficient water delivery created a divergence between the actual yield and the expected yield (i.e., what might have been attained with enough water resources). To measure the divergence, the EIA uses the IPYsim model yield under actual irrigation divided by the IPYsim yield with full water delivery. More specifically, the model yield in 2005 under actual irrigation (Below Lovewell ) is 150.5 bu/ac and the predicted yield under full irrigation is 165.9 bu. per acre (Table 10 of the EIA). The IPYsym actual yield is 90.7% of the IPYsim predicted yield under total irrigation. It appears that the EIA then assumes that the KBID reported yield of 187 bu. per acre (Table 10 of the EIA) is 90% of what might have resulted with full water delivery. The assumed full delivery yield is 206 bu. per acre, and this yield is (presumably) used in the remainder of the EIA analysis.

In my opinion, the IPYsim model is accurate in suggesting the predicted yield under actual irrigation is 90% of the predicted model yield under full irrigation. However, I do not find documentation that the percentage difference may be applied to higher yield levels with accuracy.

More specifically, the IPYsim model predicts that if the crop receives 6.12 fewer inches of water than is necessary, a yield loss of 15.4 bushels (165.9 bu. – 150.5 bu.) results. When scaled up, the EIA reports that if the crop receives 6.12 fewer inches of water a yield loss of 19.1 bushels (206.1 bu. – 187.0 bu.) results. Implicitly, at *higher base* yield generates increasingly *larger* incremental yields with additional water. I believe this to be inaccurate as the accepted relationship between applied water and crop yield is one of diminishing returns.

Given the preceding discussion, I suggest that the IPYsim model prediction for yield under full irrigation and actual irrigation be used to calculate yield loses in 2005 and 2006. Table 3 reports the alternative yield loss information using information from Table 10 of the EIA.

Table 3. Yield losses using the IPYsim yield forecasts from Table 10 of the EIA[a]

| | | Corn (bu/ac) | Milo (bu/ac) | Soybean (bu/ac) | Alfalfa (ton/ac) |
|---|---|---|---|---|---|
| **2005** | | | | | |
| Below Lovewell IPYsim Yield | | | | | |
| | Full Irrigation (bu) | 165.9 | 106.5 | 58.1 | 5.1 |
| | Actual Irrigation (bu) | 150.5 | 105.1 | 53.6 | 4.9 |
| | Difference (bu) | 15.4 | 1.4 | 4.5 | 0.2 |
| **2006** | | | | | |
| Above Lovewell IPYsim Yield | | | | | |
| | Full Irrigation (bu) | 168.3 | 108.8 | 59.6 | 5.2 |
| | Actual Irrigation (bu) | 133.9 | 99.9 | 49.7 | 4.5 |
| | Difference (bu) | 34.4 | 8.9 | 9.9 | 0.7 |
| | | | | | |
| Below Lovewell IPYsim Yield | | | | | |
| | Full Irrigation (bu) | 168.3 | 108.8 | 59.6 | 5.2 |
| | Actual Irrigation (bu) | 142.6 | 103.7 | 52.5 | 4.7 |
| | Difference (bu) | 25.7 | 5.1 | 7.1 | 0.5 |

[a]Silage has been omitted from the analysis as it was not modeled using IPYsim and it makes only 0.1% of the irrigated crop mix in KBID. Similarly, irrigated wheat is not present in the irrigated crop mix, and sunflowers are 1% or less of the crop mix in 2005 and 2006. Generally speaking, sunflowers are a non-irrigated crop.

Importantly, the yield differences in Table 3 will be reduced if supplemental irrigation is available to the KBID farmers. I am unable to verify if supplemental irrigation was available to these producers.

*Variable Costs and Fixed Costs*

The actual crop budgets used to calculate variable and fixed expenses are not included in the EIA, although the report contains specific discussion of fertilizer prices and the Kansas State University crop budget generator (an Excel model) is specifically referenced. I have been unable to evaluate the actual cost calculations used in the EIA. As an alternative, I have located crop profit center analysis for the 2001-2005 average costs and the 2006 crop costs from the Kansas Farm Management Association. The non-irrigated budgets are specific to the north central region of Kansas; however, irrigated crop costs are not available for the north central region. Therefore, the northwest Kansas farm management association cost summaries are used for irrigated crop costs. Irrigated milo costs are not available, so I have used the non-irrigated costs for the north central farm management association in their place. Sunflower costs are reported on a statewide basis.

The fixed and variable costs used in the alternative analysis are found in Table 4. I have included the land charge as part of the fixed costs.

Table 4. Variable and Fixed Costs for Various Crops ($ per acre)

| Irrigated | | Corn | Milo | Soybean | Alfalfa | | |
|---|---|---|---|---|---|---|---|
| | Variable | $ 328.45 | $ 113.09 | $ 214.87 | $ 243.45 | | |
| 2005 | Fixed | $ 85.38 | $ 53.36 | $ 59.66 | $ 133.85 | | |
| | Total | $ 413.83 | $ 166.45 | $ 274.53 | $ 377.30 | | |
| | | | | | | | |
| | Variable | $ 375.27 | $ 149.29 | $ 252.21 | $ 289.46 | | |
| 2006 | Fixed | $ 106.11 | $ 57.74 | $ 62.48 | $ 170.07 | | |
| | Total | $ 481.38 | $ 207.03 | $ 314.69 | $ 459.53 | | |
| | | | | | | | |
| Non-irrigated | | Corn | Milo | Soybean | Sunflower | Silage | Wheat |
| | Variable | $ 157.93 | $ 113.09 | $ 105.18 | $ 125.15 | $ 159.98 | $ 88.52 |
| 2005 | Fixed | $ 57.93 | $ 53.36 | $ 47.62 | $ 57.76 | $ 72.21 | $ 53.78 |
| | Total | $ 215.86 | $ 166.45 | $ 152.80 | $ 182.91 | $ 232.19 | $ 142.30 |
| | | | | | | | |
| | Variable | $ 183.44 | $ 149.29 | $ 120.37 | $ 130.12 | $ 171.44 | $ 112.00 |
| 2006 | Fixed | $ 55.48 | $ 57.74 | $ 52.93 | $ 50.38 | $ 66.91 | $ 57.64 |
| | Total | $ 238.92 | $ 207.03 | $ 173.30 | $ 180.50 | $ 238.35 | $ 169.64 |

*Profits Below Lovewell*

Using equation 1 and the aforementioned assumption on yields, prices and variable costs, I am able to calculate the foregone profits due to insufficient water delivery to the acres Below Lovewell. These foregone profits are listed in Table 5. In the table, the foregone profits are the difference between the fully irrigated profits and the irrigated profits under the actual presumed delivery of irrigation water. These profits are measured on a per acre basis, and then must be multiplied by the number of crop specific acres to amass total foregone profits. I have adopted the EIA's total acres and the respective crop mix when calculating foregone profits, but have not independently verified that these are affected acres, and foregone profits will change with differing crop mixes and irrigated acres.

Foregone profits total $589,050.24 in 2005 and $861,577.06 in 2006. These profits must be added to the foregone profits from Above Lovewell to measure the total losses due to insufficient supplies of irrigation water.

Table 5. Foregone profits for irrigated acres Below Lovewell

**Irrigated Crop Production -- Below Lovewell**

| 2005 | *Alfalfa* | *Corn* | *Milo* | *Soybeans* |
|---|---|---|---|---|
| *Total Revenue* | $ 377.40 | $ 326.82 | $ 192.77 | $ 302.12 |

| | | | | |
|---|---|---|---|---|
| *(Full Irrigation)* | | | | |
| *Total Revenue (Actual Irrigation)* | $ 362.60 | $ 296.49 | $ 190.23 | $ 278.72 |
| *Total Costs* | $ 377.30 | $ 413.83 | $ 166.45 | $ 274.53 |
| | | | | |
| *Foregone Profit ($/ac)* | $ 14.80 | $ 30.34 | $ 2.53 | $ 23.40 |
| *Crop Acres* | 1,688 | 12,563 | 1,195 | 7,688 |
| *Total Foregone Profit by Crop* | $ 24,976.60 | $ 381,145.52 | $ 3,029.12 | $ 179,899.01 |
| *Foregone Profit in 2005 (Total)* | **$ 589,050.24** | | | |
| | | | | |
| 2006 | *Alfalfa* | *Corn* | *Milo* | *Soybeans* |
| *Total Revenue (Full Irrigation)* | $ 540.80 | $ 440.95 | $ 320.96 | $ 309.92 |
| *Total Revenue (Actual Irrigation)* | $ 509.60 | $ 394.31 | $ 310.05 | $ 278.72 |
| *Total Costs* | $ 459.53 | $ 481.38 | $ 207.03 | $ 314.69 |
| | | | | |
| *Foregone Profit ($/ac)* | $ 31.20 | $ 46.64 | $ 10.92 | $ 31.20 |
| *Crop Acres* | 2,084 | 10,443 | 317 | 9,809 |
| | | | | |
| *Total Foregone Profit by Crop* | $ 65,026.04 | $ 487,042.79 | $ 3,461.76 | $ 306,046.48 |
| *Foregone Profit in 2006 (Total)* | **$ 861,577.06** | | | |

Approximately 12,817 acres were not irrigated in the Above Lovewell area (from the EIA) in 2005 and were instead planted to nonirrigated crops. Using equation 1 and the previously mentioned assumptions, the profits of the nonirrigated crops were subtracted from the foregone profits of irrigated crops. The profit for nonirrigated crops and the foregone profits to irrigated crops are listed in Table 6.

Table 6. Profit Difference of Irrigated Crop Production and Nonirrigated Production Above Lovewell (2005)

| | Corn | Milo | Soybeans | Alfalfa | Sunflower | Ensilage | Wheat |
|---|---|---|---|---|---|---|---|
| Total Revenue | $186.36 | $155.84 | $207.97 | $229.40 | $128.89 | $153.62 | $125.74 |
| Total Costs | $215.86 | $166.45 | $152.80 | $226.38 | $182.91 | $232.19 | $142.30 |
| | | | | | | | |
| Profit per Acre | -$29.50 | -$10.61 | $55.17 | $3.02 | -$54.03 | -$78.57 | -$16.56 |
| | | | | | | | |
| Crop Acres | 935.6 | 2653.1 | 1704.7 | 333.2 | 333.2 | 51.3 | 6613.6 |
| Total Profit by Crop | -$27,599.54 | -$28,146.94 | $94,042.74 | $1,006.39 | -$18,003.40 | -$4,028.08 | -$109,547.21 |
| | | | | | | | |
| Total Nonirrigated Profits | -$92,276.03 | | | | | | |

**gone Irrigated Crop Production**

| | Alfalfa | Corn | Milo | Soybeans | Sunflower | Ensilage | Wheat |
|---|---|---|---|---|---|---|---|
| Total Revenue | $377.40 | $326.82 | $192.77 | $302.12 | N/A | N/A | N/A |
| Total Costs | $377.30 | $413.83 | $166.45 | $274.53 | | | |
| | | | | | | | |
| Profit per acre | $0.10 | -$87.01 | $26.32 | $27.59 | | | |
| | | | | | | | |
| Crop Acres | 922.824 | 6869.912 | 653.667 | 4203.976 | | | |
| Total Profit by Crop | $92.28 | -$597,730.43 | $17,201.25 | $115,987.70 | | | |
| | | | | | | | |
| Total Potential Irrigated Profits | -$464,449.21 | | | | | | |
| **Difference of Irrigated and Nonirrigated Profits** | ***-$372,173.18*** | | | | | | |

The difference between foregone irrigated production and non-irrigated production is negative implying that the KBID farmers were better off planting nonirrigated crops under the 2005 market conditions.

This is largely driven by losses to corn, which suffered a net loss of $87 per acre under irrigation. Given that the producers were better off with dryland crops, an economic loss of $0 is appropriate for this specific circumstance (i.e. 2005 losses above Lovewell).

Table 6 only considers the foregone profits for the area Above Lovewell in 2005, and Table 7 enumerates the similar losses for 2006. As was the case in 2005, the Above Lovewell farmers were actually better off to have foregone irrigation in 2006. As with the previous case, this is due largely to negative profits associated with corn production.

Table 7. Profit Difference of Irrigated Crop Production and Nonirrigated Production Above Lovewell (2005)

| | Corn | Milo | Soybeans | Alfalfa | Sunflower | Ensilage | Wheat |
|---|---|---|---|---|---|---|---|
| Total Revenue | $176.33 | $217.71 | $155.48 | $280.80 | $125.22 | $199.24 | $194.84 |
| Total Costs | $215.86 | $166.45 | $152.80 | $226.38 | $182.91 | $232.19 | $142.30 |
| Profit per Acre | -$39.53 | $51.26 | $2.68 | $54.42 | -$57.69 | -$32.95 | $52.54 |
| Crop Acres | 858.7 | 2294.2 | 2332.7 | 512.7 | 166.6 | 64.1 | 6600.8 |
| Total Profit by Crop | -$33,949.39 | $117,602.90 | $6,251.62 | $27,900.05 | -$9,612.37 | -$2,111.73 | $346,770.66 |
| Total Nonirrigated Profits | $452,851.74 | | | | | | |

**Foregone Irrigated Crop Production**

| | Alfalfa | Corn | Milo | Soybeans | Sunflower | Ensilage | Wheat |
|---|---|---|---|---|---|---|---|
| Total Revenue | $540.80 | $440.95 | $320.96 | $309.92 | N/A | N/A | N/A |
| Total Costs | $459.53 | $481.38 | $207.03 | $314.69 | | | |
| Profit per acre | $81.27 | -$40.43 | $113.93 | -$4.77 | | | |
| Crop Acres | 634.064 | 3177.212 | 96.488 | 2984.236 | | | |
| al Profit by Crop | $51,530.38 | -$128,467.39 | $10,992.88 | -$14,234.81 | | | |
| Total Potential Irrigated Profits | -$80,178.94 | | | | | | |
| **Difference of Irrigated and Nonirrigated Profits** | ***-$533,030.68*** | | | | | | |

*Foregone Profit Summary*

In the previous analysis, I have assumed that irrigation water shortfall at the KBID headgates are accurate without independent analysis. The delivery shortfall leads to reduced irrigation amounts, and these too I have accepted without independent analysis. The shortfall in applied irrigation water leads to a reduction in crop yield.

In my opinion, reduced crop yields are best proxied by the use of the IPYsim model that is described in the EIA. This yield shortfall may be multiplied by the National Agricultural Statistics Service (NASS) north central district prices when calculating the total foregone crop revenues. The difference of crop revenues and total costs are then a measure of foregone profits.

Using the IPYsim model yields, NASS district prices and the Kansas Farm Management Association historical records, the foregone profits Below Lovewell totaled $589,050.24 in 2005 and $861,577.06 in

2006. In the Above Lovewell area, profits were higher with nonirrigated rather than irrigated cropping primarily because irrigated corn acres were not profitable. Thus, the economic loss due to a lack of irrigation water deliveries in the Above Lovewell area is considered to be $0. The total loss of foregone profits in the KBID is $589,050.24 + $861,577.06 = $ 1,450,627.31. This constitutes a revised gross income loss relative to that reported in the EIA.

*Indirect Impacts of Foregone Household Income*

Foregone profits represent a direct impact to the affected area. Indirect economic losses may also occur as income is reduced to farm households due to foregone profits.

The EIA assesses the indirect impacts of reduced water supplies using a Social Accounting Matrix (SAM), a regional economic model that is widely used for economic impact analysis. Though it has limitations, the SAM is able to calculate a static multiplier that tracks the impacts of reduced household incomes on all sectors of an economy. The multiplier for agricultural household spending calculated in the EIA is 1.44 (total impact divided by the direct loss in household income). While I have not been able to independently verify the SAM used in the EIA, the multiplier is consistent with my own research in the regional economic activity generated by irrigated agriculture.

In order to proxy the regional economic losses due to foregone farming profits, I will multiply the SAM multiplier from the EIA by the direct economic losses calculated previously. The total impact on household spending is 1.44*$589,050.24 = $848,232.34 in 2005 and 1.44*$861,577.06 = $1,240,670.90 in 2006. Thus, the total impact from reduced irrigation deliveries is then $2,088,903.20.

The total impact ($2,088,903.20) represents a maximum economic impact of foregone profits for a variety of reasons. First, if supplemental irrigation is used in the affected area, then both the direct impact of foregone profits will be mitigated due to higher yields, and the indirect impacts to households (lost proprietary income) are mitigated. At this time, I do not have information to evaluate whether supplemental irrigation was used.

The SAM multiplier is static in the sense that it represents a snapshot of economic activity at a point in time. In truth, if the farmers and agribusiness owners of the affected area know that irrigation restrictions will be in place, they are likely to adapt in order to mitigate lost household income. As an example, farmers may choose to provide custom farming services to others outside the affected area, they may seek to derive supplemental income from farm assets (e.g., storing grain for others or hauling goods using farm trucks) or seek off farm income. These strategies will mitigate the potential damages. Moreover, the SAM multiplier does not capture adaptations so the indirect impacts may well be overestimates of actual impacts.

*Interest Expense*

The EIA compounds interest expense on the economic losses according to the average quarterly rates for farm operating loans. The use of this rate implicitly assumes the opportunity cost of foregone profits

is to satisfy operating loans rather than other debts or that the profits would be reinvested in the farm operation.

In my opinion, the foregone profits would more likely be used to pay off term debt on land (e.g., farm mortgages), as operating loans are seldom extended into the next crop year. Operating loan balances that do require more than a year to repaid are often added to term debt. As a result, I suggest using the average annual rate on real estate debt from the Federal Reserve's Tenth District as a proxy of foregone interest in 2006 (8.35%), 2007 (8.23%) and 2008 (6.93%). In this case, the interest expense is $285,093.83 and is only accrued to lost farm profits rather than for foregone profits and indirect impacts. Foregone interest to households and government should have been captured using the SAM multiplier.

*Concluding Remarks*

For the purposes of this document, I have used the quantity of irrigation water shortfall that Golden et al posit without any independent analysis. I do not have an opinion as to whether or not delivery shortfall is correct, but a change in the shortfall quantity could affect the total damages estimated in this report.

Likewise, I am unable to independently verify the crop survey mentioned in the EIA and the KBID annual report, and do not know if it is representative of farm yields, production and prices. When appropriate, I have used NASS data and information from the Kansas Farm Management Association.

Damages are of two types: foregone profits from irrigated crop production and the indirect effects emanating from reduced household income that might be used to purchase goods. The foregone profits accrue compound annual interest according to the opportunity cost of funds. Losses are summarized in Table 8.

Table 8. Estimated Economic Losses Due to Insufficient Water Delivery By Nebraska to Kansas

| | 2005 | 2006 |
|---|---|---|
| *Foregone Profits* | $ 589,050.24 | $ 861,577.06 |
| *Indirect Losses* | $ 259,182.10 | $ 379,093.84 |
| *Interest* | $ 149,565.12 | $ 135,528.71 |
| *Total Impact* | $ 997,797.46 | $ 1,376,199.61 |
| *Sum of Impacts* | $ 2,373,997.07 | |

My alternative assessment of total impacts is $2,373,997.07. I note that the assessment can change as information is verified or new information is provided as to the extent of foregone profits and household income. I believe this to be a maximum impact (upper level) as adaption and mitigation (supplemental irrigation, new lines of business) may lead to reduced actual impacts.